State Residential High Schools for Mathematically Talented Youth

How can states promote the preparation of more highly qualified students in mathematics? One way, says Mr. Stanley, would be to establish residential high schools for the best and the brightest.

BY JULIAN C. STANLEY

FROM ACROSS the land we are hearing cries for stronger preparation of students in mathematics, so that they can meet the quantitative demands of a world increasingly dependent on scientific and technological sophistication. Harold Stevenson, Shin-Ying Lee, and James Stigler jolted many Americans into the realization that elementary school pupils in Minneapolis lag far behind their counterparts in the apparently comparable cities of Sendai, Japan, and Taipei, Taiwan.[1]

Our very best high school students seem better qualified. For example, in the annual International Mathematical Olympiad, held in Warsaw in July 1986, the six-person U.S. team competed with the best that 36 other nations could offer and tied the Soviet Union for first place. For a dozen years U.S. teams have ranked well in that event. The U.S. teams have also performed well in the International Chemistry Olympiad and in the International Physics Olympiad – even though we have participated only three times in the former and once in the latter.

These world-class performers are, however, merely the tip of the tip of the educational iceberg. They emerged, presumably, because of fortunate combinations of basic ability and special educational opportunities, mainly through extracurricular competitions at the local, state, and national levels. Their individual motivation was also quite strong. They reasoned extremely well mathematically and found fascinating those activities in which they could use their aptitude. They were highly motivated and alert to competitive opportunities.

Few mathematically and scientifically talented high school students are so fortunate. Most need an enhanced educational framework in which to learn mathematics and science far better than they could in nearly any school. In addition, they need systematic, prolonged interaction with large numbers of their true intellectual peers. As Harriet Zuckerman put it, the most outstanding scientists arise because of cumulative educational facilitation: at each stage, the potentially highest-achievers study under or associate with people who are already eminent scientists or are on the way to becoming so.[2]

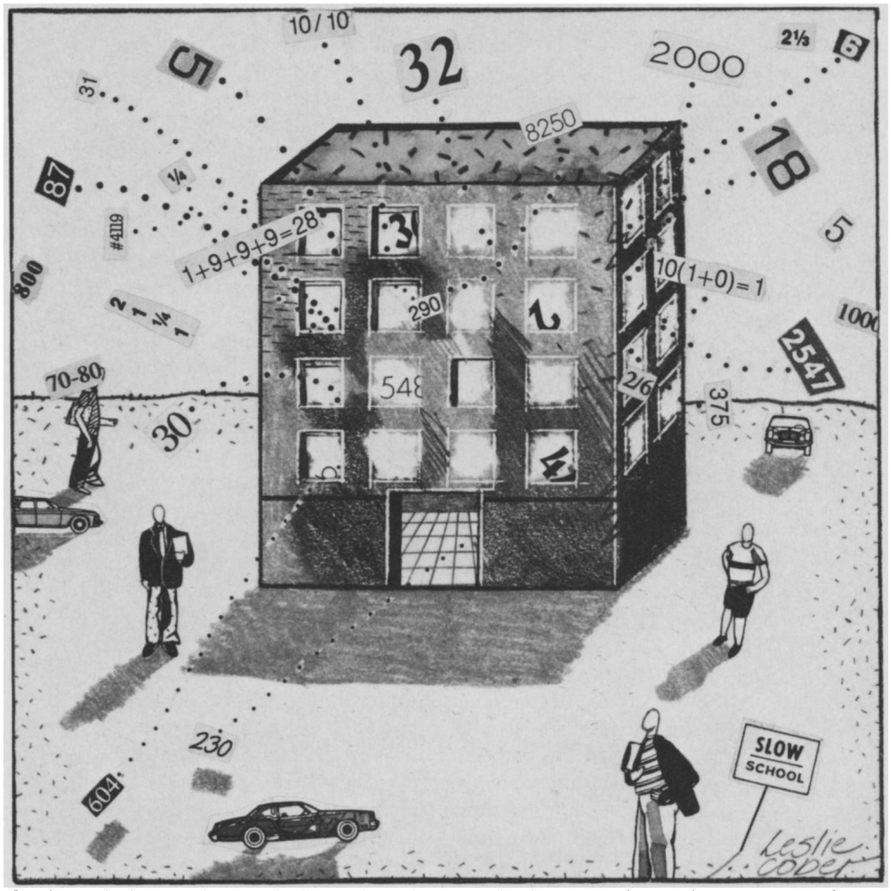
SPECIAL SCHOOLS

From the vast experience of the Johns Hopkins Study of Mathematically Precocious Youth (SMPY), which since 1971 has been identifying, helping, and following up on youths who reason exceptionally well mathematically,[3] I venture to suggest that every state in the union that has at least 300 National Merit semifinalists each year[4] should consider establishing a residential high school for science and mathematics.

Students would enter such a school at age 14 or younger, after having completed the eighth grade or its equivalent. In three intensive years, they would finish the remaining four years of high school and earn some college credits. There would be no charges for tuition, books, or room and board. Part of these expenses would be met by allocating to the school the usual cost of the student's public education in his or her locality. Industry, service clubs, and individuals could be approached to bear some of the costs, and the rest would be appropriated by the state legislature. Long-term benefits to the community, state, and nation should make such a school a wise investment.

The method of funding is critical. For example, including the school as a line-item in the state budget can make it vulnerable to the year-by-year economics of the legislature. Having it in a university's budget, instead, may be better. But this will depend on how the fiscal systems of the state and the university operate. Those who would like to start such a school should ask the directors of the three schools now operating how ef-

JULIAN C. STANLEY is director of the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University, Baltimore. *He wishes to thank Linda Brody, Susan Dauber, Ann Lupkowski, and Barbara Stanley for their editorial assistance. This article is based on a speech delivered in December 1986 at Ball State University, Muncie, Ind.*



fective their method of financing is proving to be.[5]

THE STUDENTS

Much care must be taken in selecting for the school the best-qualified youths who can be found and recruited, because the intellectual and academic caliber of the school cannot exceed that of its students. How many students should such a school admit? The entering class each year should be large enough to accommodate the ablest mathematical reasoners in the state. Using the number of National Merit semifinalists in the most populous states, California and New York, as a starting point, the *upper* limit of class size would be about 450. (I have assumed that one-third of the 1,351 potential National Merit Scholars in California would both qualify and attend.) Thus in the three grades of the high school there would be, at most, about 1,300 students.

The lower limit each year would seem to be about 100 beginning students, the ablest one in 200 of the age group. This is about the level of National Merit semifinalists, most of whom are between 16 and 18 years old. The actual number would depend on the amount of talent for science and mathematics in a particular state in a given year and on the attractiveness of the school to potential applicants.

How talented should a student be in order to be admitted? I strongly urge that a minimum ability level for an applicant in a particular state be established and that it not be subject to exception for any reason. Otherwise, political considerations and favoritism for special groups or individuals will probably be inevitable. Implicit or explicit quotas for females, members of minority groups, rural youths, and the like could seriously dilute the academic potential of the student body and adversely affect the curriculum. Of course, state legislators and others are likely to advocate exceptions, so setting an absolute minimum ability standard is crucial. If this cannot be done, then I question the wisdom of having the special school in the first place.

As an example of such a minimum criterion, I propose that each applicant's score on the mathematical part of the Scholastic Aptitude Test (SAT) be not less than the average score of male college-bound 12th-graders across the U.S. (at present, about 500) and that an applicant's combined mathematical plus verbal score be not less than the average combined SAT score of male college-bound 12th-graders (at present, about 940). This is merely an example, however. The formula for the minimum standard might be based on a state rather than a national test or, for instance, on the American College Testing Program's four-test battery rather than the SAT. The important point is that an appropriate, inflexible standard – minimum but not low – should be set from the start.

It should always be kept in mind that the minimum standard is just that: a minimum, not a norm. The ablest students in the state will benefit most from attending the school. In addition, further testing of applicants is essential. Their nonverbal reasoning ability, mechanical comprehension, ability to handle spatial relationships, knowledge of mathematics, knowledge of science, knowledge of general information, and the like should also be assessed.

Because the school is being established to improve the education of future scientists and mathematicians, special attention should be paid to students' demonstrated interest in science and/or mathematics, including projects submitted to science fairs and competitions and recommendations from the applicant's science and mathematics teachers. Of course, no objective formula exists for combining the various evidence of an applicant's fitness for the school. The admissions committee should include, but not consist entirely of, outstanding scientists and mathematicians. It should also include a testing specialist who can interpret scores for the other committee members.

RECRUITING THE FACULTY

An institution of this kind must have the best principal and the most effective teachers available. There is no place for politics, patronage, preference for local teachers, or an "old boys' " network. I recommend strongly that every instructor in the school be an experienced, successful teacher of the College Board's Advanced Placement (AP) Program curriculum in his or her subject. This will help insure an excellent grasp of the subject and a demonstrated ability to teach it to able youths.

The faculty should be recruited vigorously nationwide. Harlan Hanson, head of the AP Program since its inception in 1956, would undoubtedly be delighted to help identify prospective candidates.

Illustration by Leslie Cober

Each teacher should have at least a master's degree or the equivalent *in the subject taught*, not just in graduate education courses. Some should have academic doctorates and experience in teaching able college freshmen.

The principal of the school should be an experienced, highly successful administrator of a school or college that places considerable emphasis on science and mathematics. Assistant principals of high schools whose students tend to score high in the Westinghouse Science Talent Search – such schools as the Bronx High School of Science and Stuyvesant High School in New York City – might be well-qualified and interested in such a position. On the other hand, a successful science-trained college administrator, such as an associate dean, might be sought.

The search for the best possible principal should be both wide and thorough. Of course, the salary and fringe benefits offered would have to match the caliber of the person selected.

THE CURRICULUM

Superb students, magnificent teachers, and the best principal possible, combined with excellent facilities and a carefully planned program of studies, should virtually guarantee that the school will be worth the effort and money spent on it. I urge that the courses in mathematics, physics, chemistry, computer science, and biology aim toward the Advanced Placement Program examinations in calculus (Level BC), physics (Level C, both parts), chemistry, computer science, and biology. The *ideal* would be for every graduate of the school to have earned a 5, the highest possible grade, on each of these AP exams.

"It's the last day of school. We have to clean out our desks."

I realize full well, however, that this is an example of reaching for the stars. No school could attain the ideal of having all its graduates begin college with five two-semester courses already completed with the equivalent of A+ grades. Nevertheless, the ideal will motivate some students to do so, and each student will strive for *at least* one 4 or 5 on one of the exams.

LOCATION OF THE SCHOOL

The school itself should be located close to a highly selective college or university, so that students can quickly walk to the campus to take the college courses that they need to supplement the high school offerings. Indeed, the school could be located on the campus itself. That would eliminate the necessity for AP courses in subjects other than the five already mentioned. It would also allow students who qualify to enroll in higher-level college courses in the five core mathematics and science subjects.

By a combination of AP exams and college courses, many graduates of the school could enter college with sophomore or junior standing. They would have saved at least two years of schooling, one in high school and another in college, and this should hasten their earning a doctorate and thus provide them more years of vigorous youth in which to do creative research. I urge would-be physicians among the students to work toward the combined M.D.-Ph.D. degrees and enter medical *research*. Those who decide to follow this path might be well-advised to complete the Ph.D. degree (or nearly complete it) *first*, in order to acquire a research orientation before the clinical orientation. Moreover, those who are very much younger than the typical college graduate could find age a barrier to direct admission to medical schools.

COMPETITIONS AND SPECIAL PROGRAMS

In 1986 one student from the North Carolina High School of Science and Mathematics ranked in the top 300 in the U.S. in the annual Science Talent Search, sponsored by the Westinghouse Corporation.[6] In 1987 none did. None from the Louisiana School for Mathematics, Sciences, and the Arts qualified either year. None of the top 40 contestants came from either school in either year.[7]

By contrast, the Bronx High School of Science placed 34 students among the top 300 in 1986 and 27 in 1987; Bronx Science placed three in 1986 and five in 1987 among the top 40. Stuyvesant High School had 22 and 37 students among the top 300 in 1986 and 1987, two and five among the top 40. The Research (formerly Rickover) Science Institute (RSI), held for six weeks in the summer, produced nine students among the top 300 in 1986 and two among the top 40; in 1987 RSI placed six students among the top 300 and two among the top 40. The 100 ablest high school seniors in the SMPY yielded one in the top 40 in 1986 and three in the top six in 1987. I firmly believe that a residential state high school of science and mathematics should follow the lead of these prestigious programs by preparing *most* of its students to compete in the Westinghouse Science Talent Search when they are seniors. To do less is to underdevelop the investigative scientific spirit of highly talented students.

Each summer the U.S. sends teams to three different international academic high school Olympiads: mathematics, physics, and chemistry. In my opinion, competing for a place on one of those teams should be a major co-curricular goal of the ablest students in a state high school for math and science. Even getting into the summer training session, from which team members are selected, is usually an inspiring experience.[8]

The school should also encourage and help its students to obtain valuable scientific or mathematical experience or training during summers. There are many such opportunities, but most students won't know about them. The Research Science Institute is one. Mathematics programs, such as Professor Arnold Ross' eight-week institute at Ohio State University or the various mathematics programs at such schools as Hampshire College, are others. Enriching apprenticeships, internships, and research assistantships can also be arranged.

I could discuss many other considerations for a state residential high school of science and mathematics, but I hope

I have already said enough to provoke much discussion. Suffice it to say that this kind of planning is far more than a pleasant diversion for a wet Sunday afternoon. It requires *several years* of a state's best efforts. Our scientifically promising young people deserve nothing less.

1. Harold W. Stevenson, Shin-Ying Lee, and James W. Stigler, "Mathematics Achievement of Chinese, Japanese, and American Children," *Science*, vol. 231, 1986, pp. 693-99.

2. Harriet Zuckerman, *Scientific Elite: Nobel Laureates in the United States* (New York: Free Press, 1977).

3. Camilla P. Benbow and Julian C. Stanley, eds., *Academic Precocity: Aspects of Its Development* (Baltimore: Johns Hopkins University Press, 1983); and Julian C. Stanley and Camilla P. Benbow, "Youths Who Reason Exceptionally Well Mathematically," in Robert J. Sternberg and Janet E. Davidson, eds., *Conceptions of Giftedness* (Cambridge: Cambridge University Press, 1986), pp. 361-87.

4. For example, in 1986 California had 1,351 National Merit semifinalists, New York 1,150, Illinois 752, North Carolina 390, Indiana 384, and Louisiana 270. "Semifinalists are designated on a state representational basis. Because each state's allocation is prorated according to its percentage of the nation's high school senior class, the scores required for semifinalist standing vary from state to state. In addition, a state's qualifying score may differ from one year to the next because of variations in the number of its students who participate and the level of their test performance." See National Merit Scholarship Corporation, *Semifinalists in the Thirty-Second Annual [1987] Merit Scholarship Competition* (Evanston, Ill.: NMSC, 1986).

5. Their addresses are as follows: Stephanie A. Marshall, Illinois Mathematics and Science Academy, 1500 W. Sullivan Rd., Aurora, IL 60506-1039, Ph. 312/801-6037; Richard G. Brown, Louisiana School for Mathematics, Science, and the Arts, Natchitoches, LA 71457, Ph. 318/357-0606; and Charles R. Eilber, North Carolina School of Science and Mathematics, West Club Blvd. and Broad St., Durham, NC 27705, Ph. 919/683-6656.

6. *The 45th Annual Science Talent Search* (Washington, D.C.: Science Service, 1986); and *The 46th Annual Science Talent Search* (Washington, D.C.: Science Service, 1987). For more information about the Westinghouse program, write to Science Service, 1719 N St. N.W., Washington, DC 20036.

7. The Illinois Mathematics and Science Academy began in the fall of 1986 with only 10th-graders, so it cannot yield contestants for the Westinghouse Science Talent Search until 1989.

8. U.S. addresses for the three Olympiads are as follows: International Chemistry Olympiad, American Chemical Society, 1155 16th St. N.W., Washington, DC 20036, Ph. 202/872-4380; International Mathematical Olympiad, Mathematical Association of America, 1529 18th St. N.W., Washington, DC 20036, Ph. 202/387-5200; and International Physics Olympiad, American Association of Physics Teachers, 5110 Roanoke Pl., Suite 101, College Park, MD 20740, Ph. 301/345-4200. K

The North Carolina School of Science And Mathematics

Years before A Nation at Risk, *North Carolina was providing a special kind of education for students who demonstrated high ability and interest in science and math. Now, seven years later, what lessons can we glean from the work of the school?*

BY CHARLES R. EILBER

GIVEN THE many changes that have taken place in U.S. education recently, a little-noticed event that took place in North Carolina 10 years ago does not seem very important. Yet it may turn out to be among the most significant events of recent years. Early in 1977, soon after assuming office, Gov. James Hunt established the North Carolina School of Science and Mathematics (NCSSM) – a public residential school for academically talented 11th- and 12th-graders.

Hunt's purposes were visionary. First, he recognized that the economic well-being of a state will increasingly depend on industries whose products and services have a technological base. To provide the leadership necessary for maintaining North Carolina's competitive position with these industries, Hunt advocated a renewed emphasis on the study of science and mathematics at the high school level.

The governor's second goal grew out of the first: to improve science and mathematics education for academically talented high school students. Whether these students were currently attending schools with many or with few opportunities to develop their talents, the resources available at the new residential school would better enable them to reach their potential.

Third, Hunt sought to provide a source of new teaching methods, curriculum materials, and teacher training. What was learned in these areas at the residential school would eventually help to improve all schools in the state.

Gov. Hunt's determined efforts have given the nation a model for excellence in science and mathematics education. The North Carolina School of Science and Mathematics identifies students with the promise of becoming tomorrow's leaders and provides them with the broad educational experience they will need.

But in the beginning the school's detractors were many. Educators, legislators, and members of local school boards raised questions about cost, elitism, and the skimming off of the best students from local schools. They were skeptical of the residential requirement and fearful of political influence playing a part in the admission of students. Yet legislation was passed in 1978 establishing, under the governor's office, a state-

CHARLES R. EILBER (University of North Carolina Chapter) is director of the North Carolina School of Science and Mathematics, Durham.